Renewable energies

Wind and solar power resource evaluation

6 July 2010

At one geographical location, how can we evaluate the wind or solar energy?

- The wind energy vision

- Regional Information
  - Data available, but limited accurac

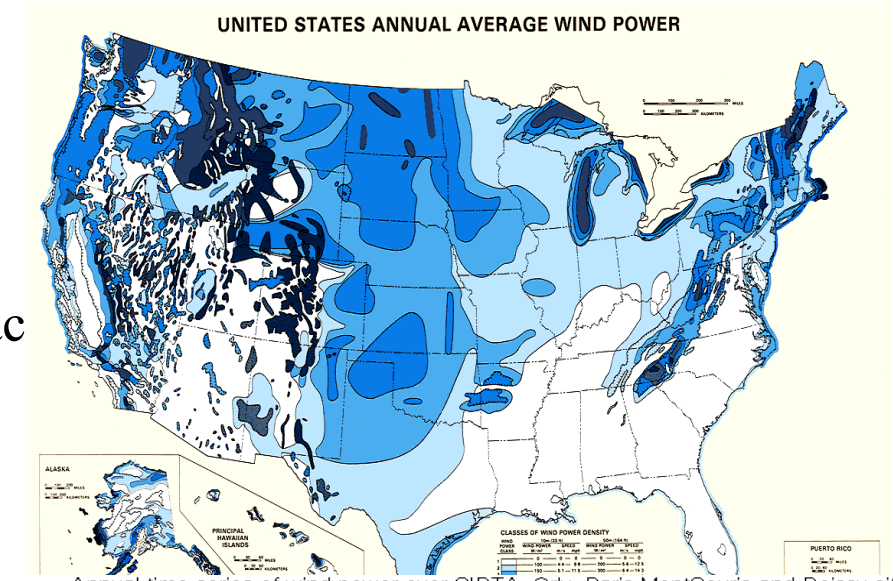
- Local Information
  - "Shape Factor" effect
  - Make measurements, different methods available:

e.g.

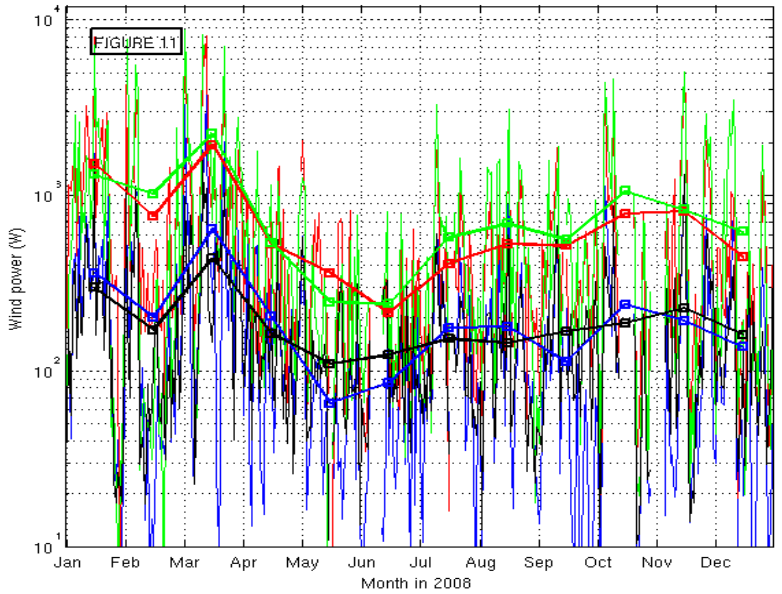
Paris potential: 827 W

Roissy potential: 195 W

(20km apart)



Annual time series of wind power over SIRTA, Orly, Paris-MontSouris and Roissy sites, daily and monthly average in 2008 at 10m altitude



At one geographical location, how can we evaluate the wind or solar energy?

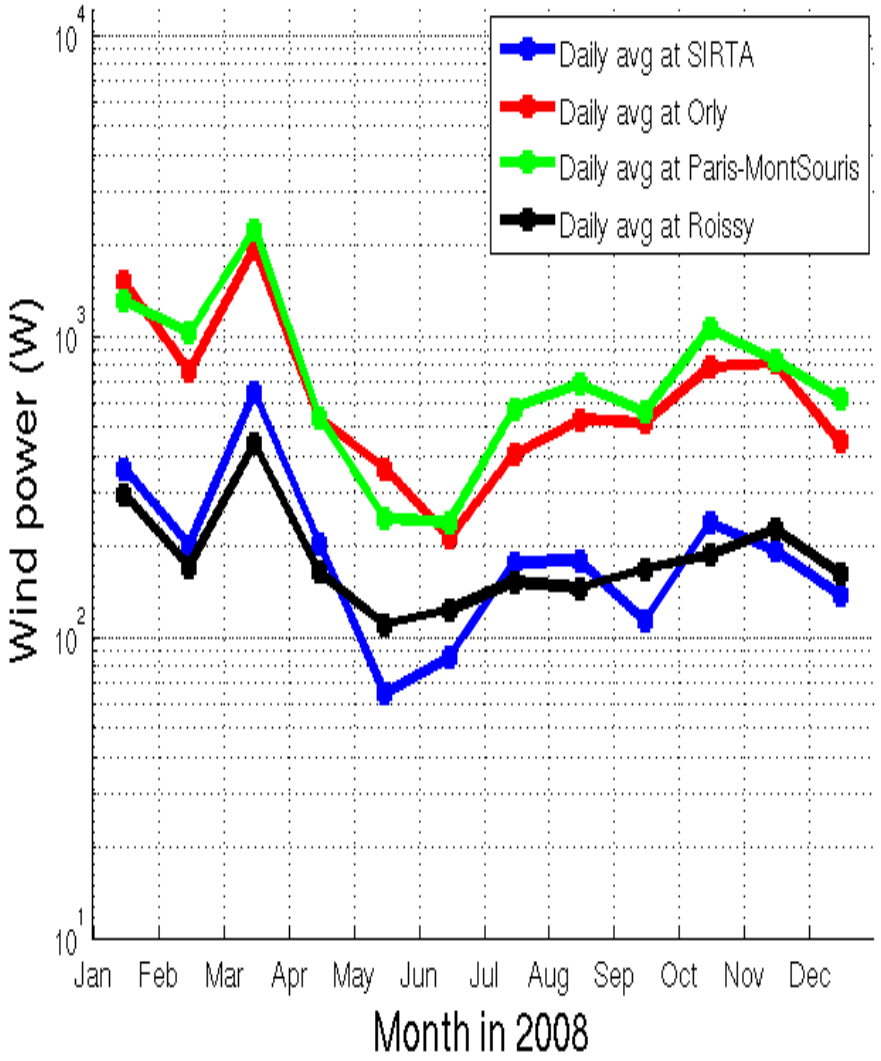
- Remote
- Techniques: Sound, Light, Radio etc.
- + Accuracy, Height
- - Complexity, Speed
- ? Business Case
  - High capital cost
  - Lower uncertainty

- In-situ
- Techniques: Physical, Sonic
- - Accuracy, Height
- + Simplicity, Speed
- ? Business Case
  - Low capital cost
  - Higher uncertainty

What is the order of magnitude of wind and solar power resource at SIRTA observatory?

- The wind energy vision

- The power obtained depends on:
  - The Ke coefficient (representing the variability of the wind speed)
  - The wind speed and direction
  - The altitude of the nacelle
  - The diameter of the wind blades
  - The geographical characteristics of the site



What is the order of magnitude of wind and solar power resource at SIRTA observatory?

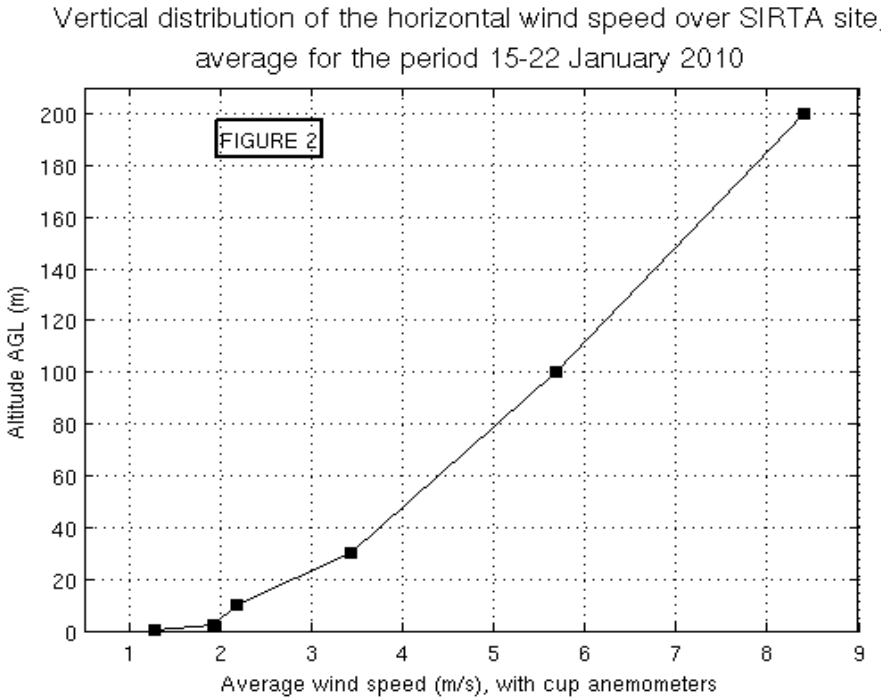
- Case Study of 10m turbines at four sites:

SITE	Average Wind Speed (m/s)	Ke coefficient	Power (W)
SIRTA	2,50	2,49	216,93
ORLY	4,14	2,15	734,06
PARIS –MONTSOURIS	3,69	2,71	827,57
ROISSY	3,00	1,81	195,33

- Case Study of one turbine for the SIRTA site:
  - At 60m (25m diameter of blades) we could retrieve an average power per m^2 of 199.7 W
  - At 80m (35m diameter) we could retrieve an average power per m^2 of 242.48 W
  - At 120m (55m diameter) we could retrieve an average power per m^2 of 341.31 W
  - At 200m (95m diameter) we could retrieve an average power per m^2 of 595.35 W

What parameters can alter the theoretical potential of wind or solar energy production?

- The wind energy vision
  - Wind Power = f (u3 , Ke)
  - Wind speed
    - Depends on the altitude

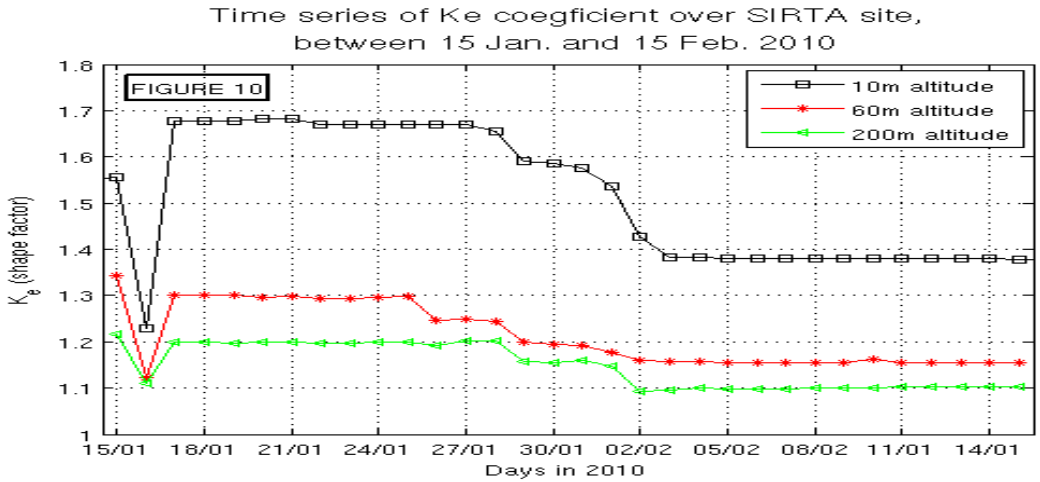


    - Depends on the site

Site	Average wind speed in 2008 (m/s
SIRTA	2.5
Orly	4.15
Paris Montso	3.7
Roissy	3

What parameters can alter the theoretical potential of wind or solar energy production?

- Variability of the wind speed (respresented by Ke coefficient)
  - Depends on the altitude



  - Depends on the geographical characteristics (buildings, trees)

Site	Ke	Average Wind power in 2008 (Wat
Sirta	2.5	217
St Quentin	2.16	734
Paris Montsouris	2.72	827
Roissy	1.81	195

How can we optimize and manage renewable energy production?

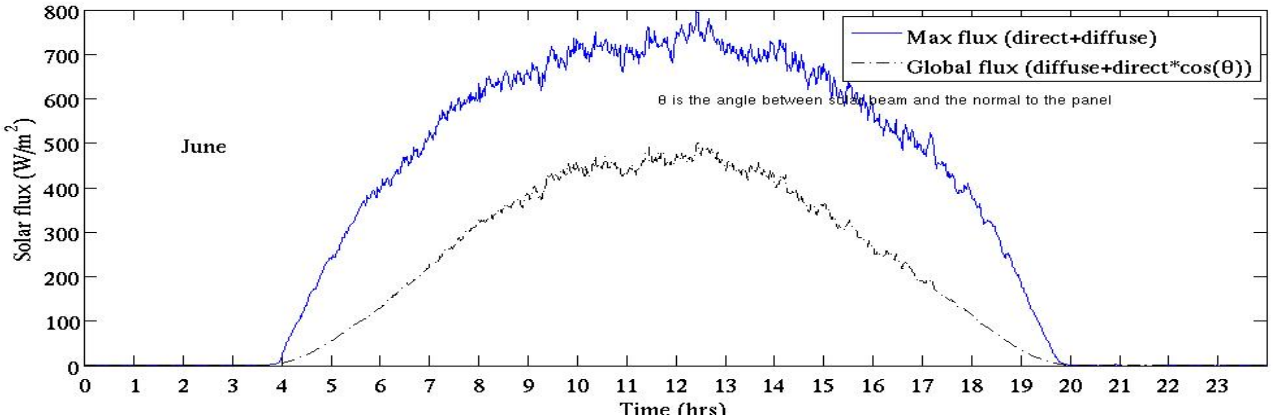
- The wind energy vision

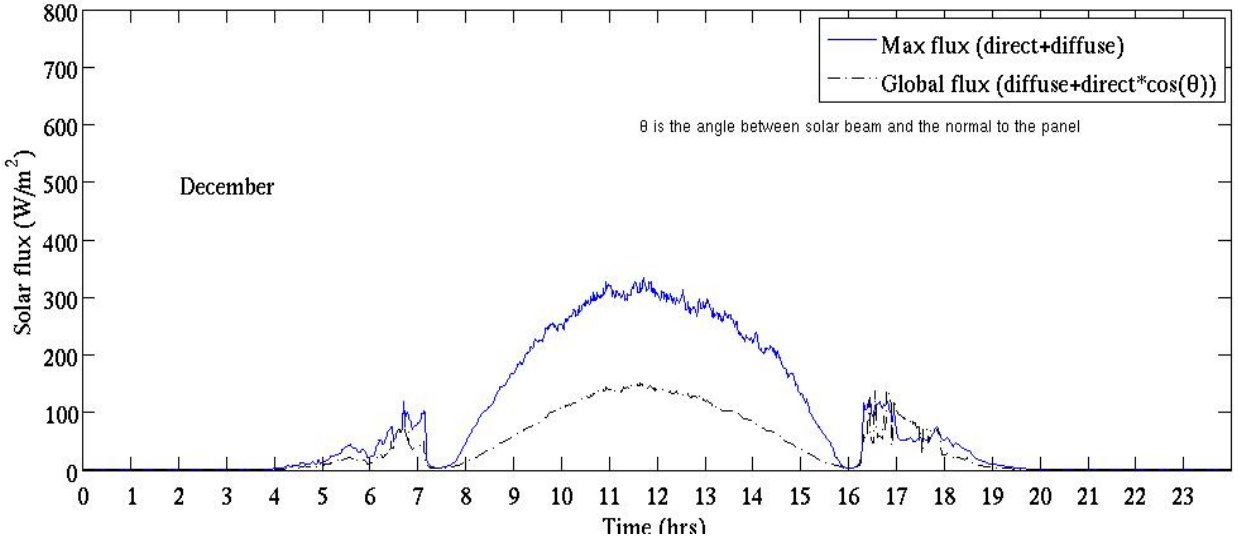
  - Increase altitude
    - Highest potential power
      - Higher average velocity
      - Less influence from the ground
    - Larger diameter
  - Managing production
    - Make wind energy more competitive
      - Decrease production cost (for larger turbines)
        - Economy of scale – How to raise demand?
      - Increase efficiency
        - Develop software tools to process the data efficiently (help will be provided)
      - Decrease running cost
        - Automate management

Introduction

- Three ways to use solar power
  - Solar thermal (electricity and hot water)
  - Passive solar (space heating)
  - Solar Photo Voltaic (PV) (electricity)
- Available power is highly location dependent
  - southern France: 1.5 MW/km2
  - Sahara desert: 32 MW/km2 (20 times more!)
- Research question: what other factors besides W/m2 affect photo voltaic power production?

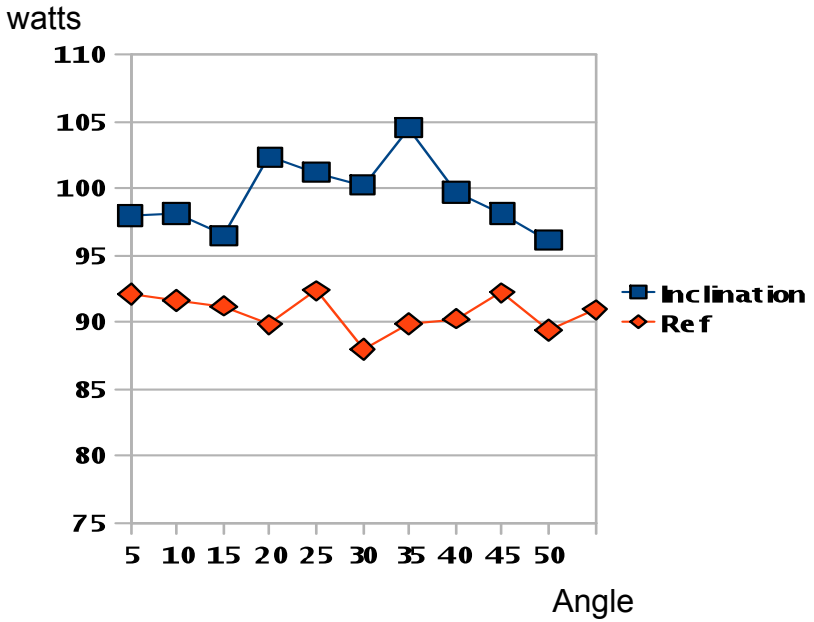
Solar Flux Assessment at SIRTA

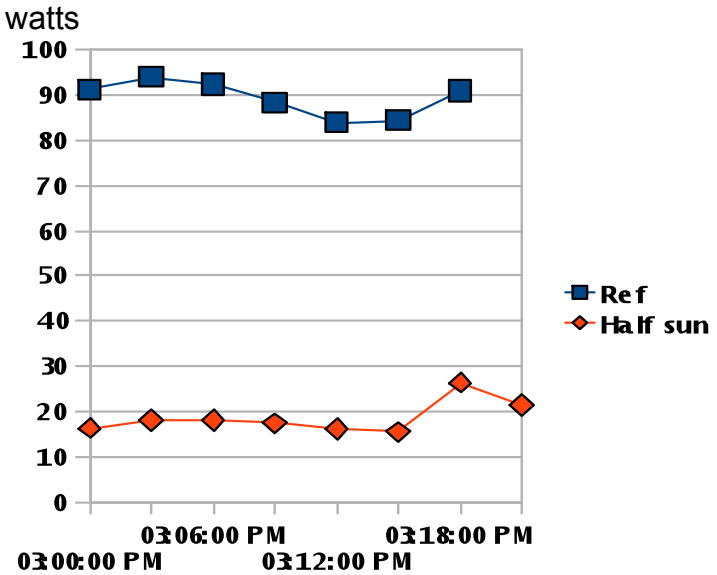


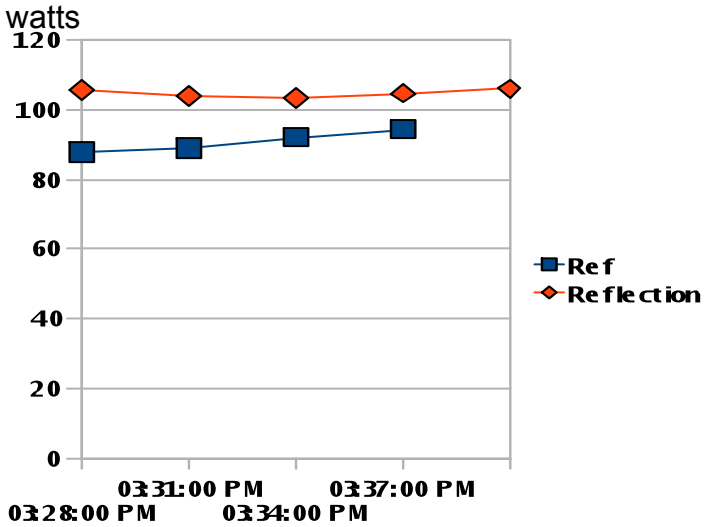


- Peak wattage in June is twice peak wattage in December
- Period of solar radiation per day is twice as long in June as in December
- Increase in efficiency of solar panel possible with tracking system (~50% increase in December, 30% in June)

Practical Experiments Solar Panel



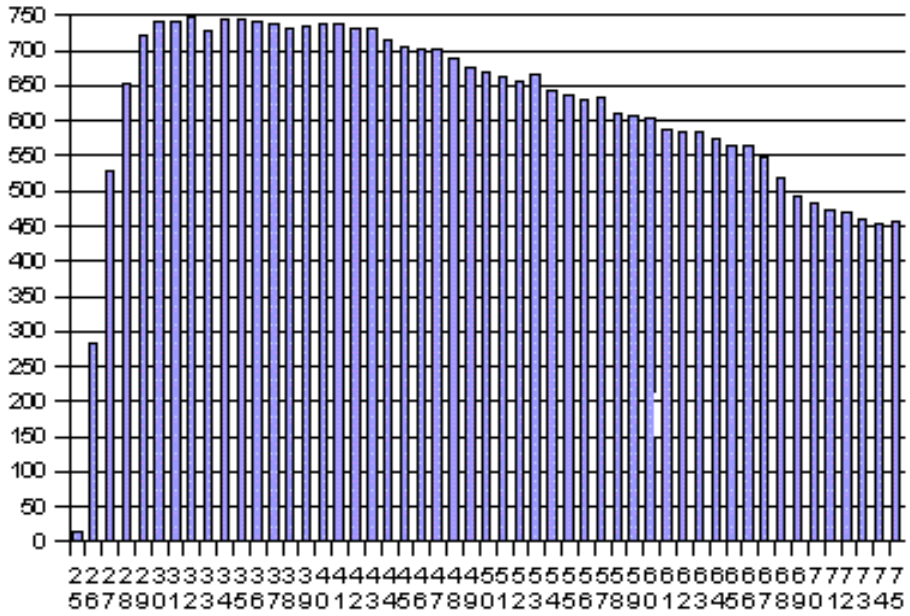




- Experiment A: Inclination has a strong effect on the efficiency of the panel (16% advantage at optimal angle)
- Experiment B: In case the solar panel is in the shadow (approx. 50%) the efficiency decreases by approx. 75%
- Experiment C: Reflection increases efficiency by approx. 16%

- PV panels are not very efficient in Europe, especially in the winter
- The energy production has to do with incoming solar radiation and efficiency of the panel, but also (at Ecole Polytechnique, 2-3pm, July)
  - Shade (80% with 50% shade)
  - Tilt of the panel (16%)
  - Reflective surfaces (16%)
- A tracking system would allow the panel to produce additional energy, but we cannot determine how much energy it would use. Also, we do not have data on the additional costs of adding such a system.

- Combining solar thermal (hot water) with solar PV would increase efficiency of panel by keeping it cool, and provide hot water.



- Sunflowers follow the sun using an organic system – maybe there is a way to mimic this tracking system, maximizing electrical output from the PV panel.